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Research Article

COMBINEDANALYSIS OF THE EFFECT OF GREEN MANURE AND DIFFERENT NITROGEN LEVELS ON THE NITROGEN AGRONOMIC EFFICIENCY IN WHEAT

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ABSTRACT
This research was carried out under the temperate climate condition of Ilam province, Iran, during 2012-2014 growing seasons to determine the suitable crop rotation for enhancing nitrogen agronomic efficiency of wheat.The experiment was performed in a split plot arrangement based on randomized complete block design with 4 replications. The main plots consisted of 6 Green manure plant treatments (Control, Perko PVH, Buko, Berssem Clover, Oilseed radish and combination of three plants Ramtil, Phasilia, Clover), and sub-plots were allocated to four levels of nitrogen fertilizer (Zero, fertilizer recommendation, 50% lower and 50% higher than the recommended fertilizer).The results showed that there were significant differences among the green manure treatments for the grain yield. The highest and lowest grain yield, with 7020, and 4969 $kgha^{-1}$ were obtained for Perko green manure and Control, respectively. The highest and lowest nitrogen uptake efficiency was obtained for Oilseed radish green manure and Fallow rotation, respectively. The difference between the various green manure was significant for nitrogen use efficiency. The green manure of Oilseed radish increased nitrogen economic performance up to 30.65 kg kg-1. The Nitrogen Uptake Efficiency in Oilseed radish green manure was the highest with 0.86 kg per kg of nitrogen. Finally among the cultivated varieties, Perko and Oilseed radish was superior compared to the other four cultivars.

Keywords: *Green Manure, Nitrogen Agronomic Efficiency, Nitrogen Recovery Efficiency, Nitrogen Use Efficiency, Wheat*
Abbreviation: NUE: Nitrogen Use efficiency, NAE: Nitrogen Agronomic efficiency, NRE: Nitrogen Recovery efficiency, NHI: Nitrogen Harvest Index

INTRODUCTION
Green manure based systems may provide alternatives to current approaches to crop production; however, the use of green manure may not be economically justified without the provision of multiple services such as nutrient supply, pest and weed control, and improvement of soil characteristics for crop production, among others. A green manure, a crop used primarily as a soil amendment and a nutrient source for subsequent crops, may provide such an alternative. Unlike synthetic N fertilizers, legumes utilized as green manure represent a potentially renewable source of on-farm, biologically fixed N and may also fix and add large amounts of C to cropping systems (Hargrove, 1986; Sharma and Mittra, 1988).
Green manures grown on site do not incur the often inhibitive handling and transportation costs of other organic inputs. The slow release of N from decomposing green manures residues may be better synchronized with plant uptake than sources of inorganic N, possibly increasing N-uptake efficiency and crop yield while reducing N leaching losses (Aulakh *et al.,* 2000; Cline and Silvernail, 2002).
The genus Brassica, there are about 160 species are mostly annuals and Biennial. This genus plants of have good potential fodder. With the progress of science breeding have been produced new varieties supply oil and forage. Perko varieties are derived from crosses tetraploid plants of winter rapeseed (*Brassica napus* L.*varnapus*) and Chinese cabbage (*Brassica campestris* L. *var. sensulato*) and new plants is superior to their parents from various directions. A Buko variety is a new amphiploid plant obtained by crossing tetraploid winter rapeseed, Chinese cabbage and turnips (*Brassica campestris* L. *var. Rapa*). Oilseed radish with scientific name (*Raphanus sativus* L.) is a genus of the Brassica and

consumption, oil, green manure, feed and fodder (Kashani *et al.,* 1986; Lupashku, 1980). This plant in many countries, including Canada, is cultivated in gardens in order to cover crop. Oilseed radish is growing quickly in the coolseasons. Ramtil (*Guizotia abyssinica*) belongs to the family Asteraceae, Phasilia (*Phaceliatana cetifolia*) is families Boraginaceae (Marianne, 1994) and clover is the legume family that are grown in order to feed.

Nitrogen (N) is often the most limiting nutrient for crop yield in many regions of the world (Guillard, 1995; Giller, 2004), N fertilizer is one of the main inputs for cereals production systems. The increase of agricultural food production worldwide over the past four decades has been associated with a 7-fold increase in the use of N fertilizers. Therefore, the challenge for the next decades will be to accommodate the needs of the expanding world population by developing a highly productive agriculture, whilst at the same time preserving the quality of the environment (Hirel *et al.,* 2007). Nitrogen fertilizer application to cereals has achieved large increases in yields; however its use is generally inefficient with on average only 33% of the total N applied actually harvested in grain (Raun and Johnson, 1999). Almost all result in estimated NUE for cereal production from 30 to 35% (Moll *et al.,* 1982). NUE may be affected by crop species, soil type, temperature, application rate of N fertilizer, soil moisture condition and crop rotation (Halvorson *et al.,* 2004). The remaining N is lost as either: surface runoff; leached nitrate ($NO3^-$) in groundwater; volatilization to the atmosphere; or by microbial denitrification, all of which pose environmental concerns (Vitousek *et al*., 1997).

Stacy *et al.,* (1992) estimated store nitrogen in the Earth is about 1.69×10^{17} ton, Since plants is used only certain forms (nitrate and ammonium) of this element, thereby limiting nitrogen as one of the main elements of plant growth is considered, and a deficiency of this element in most ecological farming systems through the use of various types of fertilizers to be compensated, Therefore, proper management of soil fertility and plant nutrition reduce nitrate pollution and maintaining biodiversity by avoiding the use of unnecessary and excessive nutrients, minimize costs and increase efficiency of inputs.

Average recovery N efficiency (REN), agronomy N efficiency (AEN) and N partial factor productivity (PFPN) in Optimum N treatment was 44%, 11 and 56 kg kg^{-1}, respectively, which were an increase of 139%, 214%, and 179% over Conventional. N treatment (REN 18%, AEN 3 kg kg^{-1}, PFPN20 kg kg-1), respectively. Sites with high NUE (REN > 60%, AEN > 15 kg/kg, PFP > 50 kg/kg) in Optimum. N treatment was 21%, 10% and 46% of all sites, respectively, while no such sites was observed in Conventional. N treatment (Cue *et al*., 2008).

Moll *et al.,* (1982) defined NUE as being the yield of grain per unit of available N in the soil (including the residual N present in the soil and the fertilizer). This NUE can be divided into two processes: uptake efficiency (NupE; the ability of the plant to remove N from the soil as nitrate and ammonium ions) and the utilization efficiency (NutE; the ability to use N to produce grain yield). This challenge is particularly relevant to cereals for which large amounts of N fertilizers are required to attain maximum yield and for which NUE is estimated to be far less than 50% (Zhu, 2000; Raun and Johnson, 1999). In addition to the improvement of N fertilization, soil management, and irrigation practices (Raun and Johnson, 1999; Alva *et al.,* 2005; Atkinson *et al*., 2005).

Dobermann (2006) reported Nitrogen Recovery Efficiency, for rice 44%, wheat, 54% and maize, 63%. Rahimi-Zadeh *et al.,* (2010) stated the frequency of maximum recovery of nitrogen in corn-wheat was 56% and sugar beet-wheat was 48%. Nitrogen use efficiency for wheat following legumes is greater than that for wheat following fallow or continuous wheat.

Lopez-Bellido and Lopez-Bellido (2001) showed that nitrogen efficiency indices significantly affected by crop rotation and N fertilizer rate. Yamoah *et al*., (1998), studying particular N efficiency indices, concluded that efficiency is greater in crop rotation systems than in monoculture systems.

Rahimizadeh *et al*., (2010) reported that significant differences between preceding crops were observed for NUE, NUpE, NUtE, and NHI. The highest NUE, NUpE and NUtE were obtained for potato-wheat, while continuous wheat recorded the lowest NUE indices. Nitrogen fertilizer rates had a significant effect on NUE, NUpE and grain protein content in each rotation, but NUtE and NHI were not significantly affected by N fertilizer rate. And NUE decreased with increasing N rate. Some of the general purposes of crop rotation are: to maintain soil structure, increase soil organic matter, increase water use efficiency, reduce soil erosion, reduce the pest infestation, reduce reliance on agricultural chemicals and improve crop nutrient use efficiency (Halvorson *et al.,* 2001).

According to Delogu *et al.,* (1998) nitrogen use efficiency indicators of reduced with increasing amounts nitrogen fertilizer, that show the usefulness of nitrogen is low in these conditions. Zhao *et al.,* (2006) also reported the use of nitrogen fertilizer in moderation and optimization of the periodic system in wheat: corn nitrogen use efficiency than the conventional system with excessive nitrogen fertilization rate of about 3.5 fold increase.

Hossaini *et al.,* (2013) with increasing nitrogen application, NUE significantly between all levels of the nitrogen fertilizer is reduced. NUE index difference between the two conditions do not apply N fertilizer (control) and maximum nitrogen (270 kg N ha) is 44%. Also by increasing nitrogen fertilizer, NUpE decreased.

Winter wheat based rotations are main cropping system in Iran, but little information exists on better rotation for wheat under temperate climate in Iran. Conventional crop rotations are not much diverse and all with short periods. An improved understanding of NUE of wheat is needed to increment sustainability of winter wheat base rotations. According to Miller *et al.,* (2002) types of plants can be grown in the years before the creation of the different conditions in the soil (nitrogen availability, organic matter, and available water volume) should be further improved plant performance. The objectives of this research were to evaluate the effects of rotation, N fertilizer rate on N efficiency indices of wheat.

MATERIALS AND METHODS

Experimental Site and Design

The field experiment was conducted from 2011 to 2014 at the Karezan region of Ilam, Iran (42º33′N, 33º46′ E) on a Silty- Clay with low organic carbon (1.26%and slightly alkaline soil (pH=7.9). Other soil test parameters are presented in Table 1.This site characterized by temperate climates with 370 mm annual precipitation.

Table 1: Results of soil tests implementation of experimental site

Soil depth $_{(cm)}$	Soil Texture	P $_{(ppm)}$	K$_{(ppm)}$	N%	OC%	pH	EC$_{(ds/m)}$
0-30	Silty- Clay	10.5	760	0.11	1.26	7.9	0.58
30-60	Silty- Clay	4.4	420	0.07	0.76	7.8	0.58

Design and application of treatments

The experiment was arranged in a split plot based on randomized complete block design with four replications. The main plots consisted of 6 green manure plant treatments (Control, Perko PVH, Buko, Berssem Clover, Oilseed radish and combination of three plants Ramtil, Phaselia, Clover), and Sub plots were four N fertilizer rates including no fertilizer N(Control), 50% lower than recommended N rate, recommended N rate and 50% more than recommended N rate.

Winter wheat (Cv. Pishtaz) was planted on mid-November with arrow spacing of 15 cm and a seeding rate 200 kg ha^{-1}. Soil samples were taken after harvest of each crop from the 0 to 30 cm and 30 to 60 cm soil depths using a soil Auger. Wheat grain yield (14% moisture) obtained by harvesting the center 3 m by 10 m with a plot combine, but yield components were determined from two randomly selected areas (2m^2) within each plot. Plant samples collected at harvest were separated into grain and straw and oven-driedat 60˚C for 72hr. Biomass and grain sub samples analyzed for total N content using a micro-Kjeldahl digestion with sulfuric acid.

Statistical Analysis

The terminology of N efficiency parameters is according to Delogu *et al*., (1998) and Lopez-Bellido amd Lopez-Bellido (2001), Rahimizadeh *et al*., (2010), Limon-Ortega *et al*., (2000), Moll *et al.,* (1982), Timsina *et al.,* (2001), Abbasi *et al.,* (2005), Sowers *et al.,* (1994), Fan *et al.,* (2004).

1)-Nitrogen Agronomic Efficiency (NAE)

$(NAE) = \frac{\text{YNx} - \text{YN}0}{\text{FN}}\text{Y}$

Nx = Total yield of crop rotation per unit area of kilogram of fertilizer treatments.
Y N0 = Total yield in kilograms per unit area of crop rotation control that did not receive fertilizer
FN = N fertilizer consumption in kgper unit area.

2)-Nitrogen Recovery Efficiency (NRE)

$$(NRE) = \frac{(D - \text{E})}{FN} \times 100$$

D= total nitrogen uptake by crops in rotation, in kilogram per unit area in the fertilizer treatments for each plant is (nitrogen concentration × grain yield per unit area) + (dry weight of residue per unit area × N concentration).

E= total nitrogen uptake by crops in kilogram per unit area in control (no fertilizer).Which is equal for each plant (dry weight per unit area × nitrogen concentration) + (dry weight of residue per unit area × nitrogen concentration).

3)-N Harvest Index (NHI)

$$(NHI) = \frac{Ng}{D} \times 100$$

Where Ng is total grain N uptake. Ng was determined by multiplying dry weight of grain by N concentration.

4)- Nitrogen Use Efficiency (NUE)

(NUE, kg kg^{-1}) = GY/N_{supply}

Where G.Y is grain yield and N_{supply} is sum of soil N content at sowing, mineralized N and N fertilizer. According to Limon-Ortega *et al.*, (2000), N_{supply} was defined as the sum of (i) N applied as fertilizer and (ii) total N uptake in control (0 N applied).

5)- Nitrogen Uptake Efficiency

(NUpE, kg kg^{-1}) = Nt / N_{supply}

Where Nt is total plant N uptake. Nt was determined by multiplying dry weight of plant parts by N concentration and summing over parts for total plant uptake.

The differences between the treatments were determined using analysis of variance (ANOVA). Mean comparisons were performed using Duncan`s multiple range test procedures by the SAS software.

RESULTS AND DISCUSSION

Total Economic Yield (TEY)

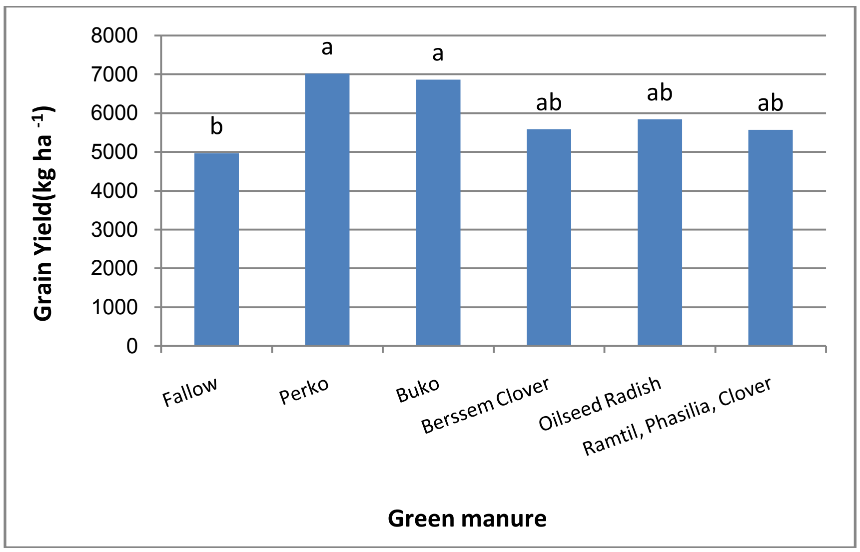

Figure 1: Wheat grain yield affected by preceding crop

Results showed that the effect of green manure were significant (*P≤0.05*) on the economic performance of the entire green manure. The highest (7020.6 kgha^{-1}) and lowest (4969.4kgha^{-1}) TEY of wheat were observed for the Perko green manure and Control, respectively (Figure 1). Effect of nitrogen fertilizer was significant (*P≤0.01*) on the economic performance of alternative treatments. The highest (6488.6kgha^{-1}) and lowest (5278.1kgha^{-1}) TEY of wheat were observed for the 50% less N than recommended rate and control (no fertilizer), respectively.

Nitrogen Agronomic Efficiency (NAE)

The results of combined analysis showed that the nitrogen agronomic efficiency in the six rotation tests were significantly different ($P \leq 0.05$) (Table 2). Oilseed radish green manure was highest NAE so that consumption of nitrogen per kilogram of the green manure plant increased the economic performance of 17.06 kg ha^{-1}. While the Buko green manure lowest NAE, For every kg nitrogen consumption increased the economic performance of 5.53 kg ha^{-1} (Table 3).With the increased of nitrogen application except fallow- wheat rotations Nitrogen agronomic Efficiency decreased in other crop rotations, The highest (17.55 kgkg^{-1}) and lowest (8.34kgkg-1) NAE of wheat observed for the applay nitrogen 50% lower than recommended rate and N Recommended rate, respectively (Table 3). The interactive effects of nitrogen fertilization and green manure plants, The highest (17.17 kgkg^{-1}) NAE of wheat observed for the N Recommended rate and Oilseed radish green manure, and lowest (4.7 kg) NAE of the 50% more than recommended rate N and bukogreen manure, respectively(figure 2).The results showed that the cultivation of oilseed radish reduced nitrogen consumption can lead to decreased yield, While the rest of the rotation system due to the positive effects of rotation the sensitivity yield is less nitrogen fertilizer. Lopez-Bellido and Lopez-Bellido (2001), Rahimizadeh *et al*., (2010), Abbasi *et al.,* (2005) Thuy *et al.,* (2008), Cui *et al.,* (2005) also reported that the interaction of crop rotation and nitrogen fertilization on the NAE was significantly and decreased NAE with increasing nitrogen.

Nitrogen Use Efficiency

The results of combined analysis showed that NUE of wheat affected by preceding crop and year was no significant and nitrogen fertilizer rate in preceding crop and interaction between N rate and crop rotation and interaction between N rate and year was significant (Table 2). The highest and lowest NUE of wheat observed in Oilseed radish: Wheat (30.65 kg kg^{-1}) and Buko: Wheat (23.22 kg kg^{-1}) rotations, respectively (Table 3). The NUE of wheat grown after Oilseed radish was 25% more than wheat NUE in Buko: Wheat system (Table 3). In addition, the lowest NUE of wheat were always associated with the 50% more than recommended rate regardless of preceding crops. Whereas, according to Moll *et al.,* (1982), NUE multiplying N uptake efficiency by the N utilization efficiency, these finding support the conclusion that low NUE of continuous wheat is related to its low grain yield and NUpE compared with the other rotations.

Based on the comparison of means, with the increase of N fertilizer efficiency is reduced, so that the highest and lowest NUE of wheat were found in no application control (no N) (35.49 kg kg^{-1}) and 50% more than the recommended (21.9 kg kg^{-1}), respectively (Table 3). Similar results Lopez-Bellido and Lopez-Bellido (2001) Raun and Johnson (1999) and Montemuro *et al.*, (2006) based on crop rotation and a nitrogen fertilizer effect on NUE was reported. Power *et al.,* (2000), Hossaini *et al*., (2013) and Rahimi-Zadeh *et al.,* (2010) Sowers *et al.,* (1994), Limon-Ortega *et al.,* (2000) and Zhao *et al.,* (2006) reported similar results and indicated that NUE decreased with increases N rate, Moll *et al.,* (1982) reported That the highest NUE usually attracts is obtained by first fertilizer unit and its efficiency decreases with increasing fertilizer. The highest nitrogen use efficiency were in the second year of without N fertilizer treatment (36.12 kg kg^{-1}) and the lowest NUE of wheat observed in first year and use nitrogen 50% more than recommended (22.32kg kg^{-1}), respectively (Table 4).

Nitrogen Recovery Efficiency (NRE)

The results showed that NRE of wheat affected by Green manure plant and nitrogen fertilizer rate in Green manure plant and interaction between N rate and Green manure plant was significant (Table 2). The highest and lowest NRE of wheat observed in Oilseed radish Green manure (46%) and Fallow (5.6%) rotations, respectively (Table 3). The high NRE in oilseed radish Green manure indicate that the loss of nitrogen in the soil is less than other Green manure plant. But nonetheless remained about half of the use nitrogen fertilizer in the soil as organic or lost. Rahimizadeh *et al*., (2010) have a positive impact on the efficiency of the rotations system has been approved by NRE. Until the optimum use fertilizer nitrogen conditions NRE of the process will increased and then decrease with increasing use nitrogen. Rahimizadeh *et al.*, (2010), Sieling *et al.*, (1998) and Zhao *et al.*, (2006) have reported NRE decreases with increased of nitrogen consumption.

Nitrogen Uptake Efficiency

Nitrogen uptake efficiency reflects the efficiency of the crop in obtaining N from the soil. Increased NUpE has been proposed as a strategy to increase NUE by Raun and Johnson (1999). Results of combined analysis showed that wheat NUpE was affected by Green manure plant and year and N fertilizer rates. Moreover, there was a significant difference interaction between Green manure plant and N rate and interaction year and nitrogen for NUpE (Table 2). The highest (0.84kg kg^{-1}) and lowest (0.78kg kg^{-1}) NUpE of wheat were observed for the year2013 and 2014, respectively. NUpE rate in 2013 year better than NUpE in 2014 year. The highest (0.89kg kg^{-1}) and lowest (0.65kg kg^{-1}) NUpE of wheat observed for the Oilseed radish Green manure and fallow-wheat rotations, respectively (Table 3). According to Moll *et al.*, (1982), variation in NUpE could be separated from grain yield variation. In addition, Lopez-Bellido and Lopez-Bellido (2001) indicated that differences between rotations with respect to grain yield, which is directly related to crop N uptake, account for the variation in the NUpE index. Lee *et al.*, (2004) indicated that NUpE was positively correlated with plant dry matter, leaf area index and leaf nitrogen content. So, this result could explain by wheat yield variation in crop rotations. Oilseed radish Green manure and Perko Green manure in terms of nitrogen 50% lower than recommended rate, the highest NUpE (0.92 and 0.87 kg kg^{-1}) respectively, and fallow: wheat rotation in terms of nitrogen 50% more than recommended rate were the lowest NUpE (0.58 kg kg^{-1}).

Therefore, the higher mean of NUpE in wheat for oilseed radish Green manure and perko: Green manure was due to higher grain yield compared with other rotations. Results indicated that, NUpE of wheat decreased with each incremental addition of N fertilizer and the lowest NUpE in each rotation was for maximum N rates (Table 3). In oilseed radish Green manure applying N maximum rate, decreased wheat NUpE15.2% compared with control (no N). While, NUpE of wheat decreased 30% in continuous wheat system with applying 50% lower than recommended N rate. Our results agreed with those of Lopez-Bellido and Lopez-Bellido (2001), Rahimizadeh *et al.*, (2010), Husaini *et al.*, (2013), Ortiz *et al.*, (2002), and Zhao *et al.*, (2006), Nasri *et al.*, (2014) who found that on NUpE decreased with increase N use rate. The highest NUpE of wheat was observed for the interaction of oilseed radish Green manure and nitrogen fertilizer, in the treatment of 50% less N than recommended rate (0.99kgkg^{-1}) and the lowest NUpE of wheat were observed for the interaction, fallow: Wheat rotations and nitrogen fertilizer, in the treatment50% more than recommended rate (0.42kg kg^{-1}), respectively. The highest NUpE of wheat observed for the interaction of nitrogen and year, in the treatment 50% lower than recommended rate and first year (0.87kg kg^{-1}) and the lowest NUpE of wheat observed for the interaction,50% more than recommended rate and in the second year (0.73kg kg^{-1}), respectively (Table 4).

Nitrogen Harvest Index (NHI)

The N harvest index, defined as N in grain to total N uptake, is an important consideration in cereals. NHI reflects the grain protein content and thus the grain nutritional quality (Hirel *et al.*, 2007).Results indicated that NHI of wheat varied significantly with green manure plant (Table 2). The lowest and highest value for NHI observed in Oilseed radish green manure (80.2%) and perko and Boku- green manure (83.5%), respectively. In other words, the green manure Boku nitrogen uptake by more than 83% of the harvested crop is concentrated economic, while in other green manure plant flower proportions of nitrogen uptake by plants grown in economic output is accumulated, Oilseed radish green manure NHI of wheat was significantly lower than other rotations. These results agreeing with the finding of Delogu *et al.*, (1998) who reported that NHI in continuous wheat was significantly different with crop rotations.

NHI was affected by N rate and none of the green manure plant ×N rate interactions were significant. The lowest and highest value for NHI observed in apllay nitrogen 50% more than recommended rate (81.2%)

and 50% lower than recommended rate (84.2%), respectively. Montemurro *et al.*, (2006) suggested that grain N uptake was positively correlated with yield, protein content and total N uptake and a significant positive correlation found in NHI, yield and total N uptake. Lopez-Bellido and Lopez-Bellido (2001), Nasri *et al.*, (2014) showed that the increase in crop N uptake with rising N fertilizer rates was greater than the increase in grain yield, so there is less transfer of N to grain when N rates was increased.

Table 2: Combined analysis of NUE, NAE, NUpE ,NHI , NRE

S.O.V.	df	NAE	NUE	NUpE	NHI	NRE
year	1	344.1 ^{ns}	293.2 ^{ns}	22.56 ^{ns}	59.87 ^{ns}	1125.7
Year ×Replication	6	181.22	53.81	80.39	54.71	1298.3
green manure plant	5	472.2 ^{ns}	220.61 ^{ns}	647.9**	126.4 ^{ns}	6299.9**
Year ×green manure plant	5	76.5 ^{ns}	44.52 ^{ns}	17.13 ^{ns}	76.12 *	1774.3 ^{ns}
E(a)	30	285.46	27.89	37.67	93.75	2069.4
Nitrogen	3	1149 **	1638.6 *	53.81 ^{ns}	87.98 **	2380.6**
Nitrogen ×green manure plant	15	209.6 ^{ns}	68.12 **	37.33 **	143.9 ^{ns}	1504.5 ^{ns}
Year × Nitrogen	3	178.9 ^{ns}	111.9 **	8.55 ^{ns}	34.17 ^{ns}	864.6 ^{ns}
× Nitrogen×green manure plant Year	15	107,3^{ns}	6.49 ^{ns}	1.358 ^{ns}	2.76 ^{ns}	135.7 ^{ns}
E(b)	108	153.5	7.88	4.88	3.12	529.7
C.V	-	23.5	2.8	5.51	6.12	17.21

Table 3: Mean comparisons of combined analysis of NAE, NUE, NUpE, NHI, NRE

Treatment	NAE ($kg\ kg^{-1}$)	NUE ($kg\ kg^{-1}$)	NUpE ($kg\ kg^{-1}$)	NHI (%)	NRE ($kg\ kg^{-1}$)
		Years			
Year 2013	10.14 ^{a}	29.01 ^{a}	0.84 ^{a}	82.1 ^{a}	25.16 ^{a}
Year 2014	9.27 ^{a}	39.54 ^{a}	0.78 ^{b}	82.8 ^{a}	21.95 ^{a}
		Green manure crop			
Fallow	8.08 ^{ab}	26.87 ^{ab}	0.65^{b}	83.5 ^{a}	10.49 ^{ab}
Perko	7.92 ^{ab}	23.22 ^{b}	0.86 ^{a}	83.6 ^{a}	7.86 ^{ab}
Buko	5.53 ^{b}	26.87 ^{ab}	0.79 ^{ab}	83.5 ^{a}	4.47 ^{b}
Clover	9.14 ^{ab}	29.27 ^{a}	0.83 ^{a}	82.4 ^{ab}	17.82 ^{ab}
Ramtil, Phacilia, Clover	12.89 ^{ab}	27.34 ^{ab}	0.83 ^{a}	81.2 ^{ab}	28.7 ^{a}
Oilseed radish	17.06 ^{a}	30.65 ^{a}	42.3 ^{a}	80.2 ^{b}	42.83 ^{a}
		N rate			
Control (no fertilizer)	-	35.49 a	1 ^{a}	82.3 ^{b}	-
50% lower than recommended rate	17.55 ^{a}	28.65 ab	0.84 ^{ab}	84.2 ^{a}	25.14 ^{a}
Recommended rate	8.34 ^{b}	25.02 b	0.73 ^{bc}	81.9 ^{b}	20.07 ^{a}
50% more than recommended rate	8.89 ^{b}	21.9 b	0.67 ^{c}	81.2 ^{b}	14.27 ^{ab}

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Table 4: Comparing the mean of combined analysis NUE, NAE, NUpE, NHI, NRE

Green manure	**Nitrogen levels**	**NUE (kg kg^{-1})**		**NUtE (kg kg^{-1})**	
Fallow	*N0*	24.1 ^{b}	39.7 ^{a}	40 ^{a}	39.68 ^{bc}
	N1		25.3 ^{gh}		39.93 ^{bc}
	N2		17.01 ^{no}		44.59 ^{a}
	N3		14.43 ^{o}		35.77 ^{dfe}
Perko	*N0*	27.67 ^{a}	35.03 ^{bc}	34.3 ^{bc}	35.03 ^{efg}
	N1		29.42 ^{ef}		35.69 ^{ef}
	N2		23.81^{hjk}		33.97 ^{fghj}
	N3		22.44^{hjkl}		e32.53 ^{ghj}
Buko	*N0*	25.58 ^{ab}	29.32 ^{ef}	31.3 ^{c}	29.31 ^{k}
	N1		27.33 ^{fg}		32.23 ^{hjk}
	N2		24.42 ^{ghj}		31.73 ^{jk}
	N3		21.28 ^{klm}		31.79^{jk}
Berssem Clover	*N0*	28.08 ^{a}	39.04 ^{a}	37.8 ^{a}	39.39 ^{bc}
	N1		31.32 ^{def}		41.55 ^{ab}
	N2		22.02 ^{jklm}		34.83 ^{fgh}
	N3		19.51 ^{m}		35.27 ^{ef}
Ramtil, Phacelia, Clover	*N0*	25.87 ^{ab}	33.23 ^{cd}	33.8 ^{bc}	33.23 ^{fghj}
	N1		26.95^{fgh}		34.18 ^{fghj}
	N2		22.55 ^{hjk}l		33.11^{fghj}
	N3		20.77 ^{lm}		34.68 ^{efgh}
Oilseed radish	*N0*	27.9 ^{a}	37.26 ^{ab}	36.7 ^{ab}	37.25 ^{cde}
	N1		31.48 ^{de}		38.84 ^{bcd}
	N2		23.51 ^{hjkl}		36.09 ^{def}
	N3		19.35 ^{mn}		34.47 ^{fghj}

N0= Control (no fertilizer), N1=Nitrogen 50% lower than recommended rate, N2= Recommended rate of Nitrogen, N3= Nitrogen 50% more than recommended rate

Conclusion

Significant differences between green manure were observed for NUpE, NRE and TEY content of wheat. The highest NUE, NUpE, NRE and TEY were obtained for oilseed radish green manure. Nitrogen fertilizer rates had a significant effect on NUE, NRE, NAE and TEY content in each green manure, but NUpE were not significantly affected by N fertilizer rate. This study showed that NUE, NUpE, NAE, NRE and NHI decreased with increasing N rate. Interaction between green manure plant and Nitrogen had a significant effect on NUE, NUpE.

A total, all index nitrogen efficiency decreased rate with increasing nitrogen. There was no significant difference between years of NUE, NUtE and NER traits experiments. The highest and lowest grain yield, with 7020, and 4969 kgha^{-1} were obtained for Perko green manure and Fallow: Wheat rotation, respectively. The highest and lowest nitrogen uptake efficiency was obtained for Oilseed radish green manure and Fallow: Wheat rotation, respectively. The difference between the various green manure plants was significant for nitrogen use efficiency. Finally among the cultivated varieties, Perko and Oilseed radish was superior compared to the other four cultivars.

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